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Forest Pest Management Report

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WESTERN SPRUCE BUDWORM SUPPRESSION AND
EVALUATION PROJECT USING CARBARYL--1977

Santa Fe National Forest and
Jemez Pueblo Indian Reservation
New Mexico

Progress Report No. 7
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By

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INTRODUCTION

In 1977, a suppression project was conducted to evaluate the prolonged effects of an insecticide treatment on a building western spruce budworm, Choristoneura occidentalis Free., outbreak to determine if a "population reduction strategy" was a viable alternative. Carbaryl (Sevin 4 oil[1]) was aerially applied to 37,450 acres of forested land in an isolated mountain range on the Santa Fe National Forest and the Jemez Pueblo Indian Reservation. Objectives of the project were to: (1) Suppress the budworm population to such a low level that mating becomes less likely, parasites and predators become more significant in regulating the population, and density-independent factors, such as weather, keep the budworm population below an economically damaging level; (2) evaluate the effectiveness of suppression for a 2-year period in the treated area and a comparable untreated check area (37,398 acres); and (3) evaluate and compare annual defoliation and tree damages in the treated and untreated areas.

The application phase of the project was successfully completed in 1977 (Parker et al. 1978). Criteria established to show treatment success were: (1) Reducing the budworm larval density by an average of 90 percent and (2) obtaining an egg mass density of less than 1.5 new egg masses per square meter of foliage. The 1976-77 budworm generation was reduced by an average of 93.1 percent, compared with a 44.5 percent reduction in the untreated area. The adjusted budworm mortality, using Abbott's formula, was 87.5 percent. One larva per 100 buds of Douglas-fir remained 14 days following treatment. The average density of new egg masses was 1.6 per square meter in the treated area and 9.9 per square meter in the untreated area. Although an average of 84.1 percent of the budworm larvae were in the fifth and sixth instars and 0.3 percent were pupae at the time of treatment, defoliation was considerably lower than that recorded in the untreated area: Treatment area--26.5 percent for Douglas-fir and 37.0 percent for white fir; untreated area--40.8 percent for Douglas-fir and 61.3 percent for white fir.

Sampling for larval densities, number of egg masses, and defoliation on the plots was done in 1978 and 1979 to determine whether suppression effects continued. Larval and egg mass densities and defoliation remained at low levels for both years in the treated areas, and increased in the untreated area (Parker et al. 1979, Parker and Ragenovich 1980).

Sampling for egg mass densities, defoliation, apparent top-kill, and mortality of seedlings and saplings was continued in 1980 (Ragenovich and Parker 1981) and 1981 (Telfer et al. 1982). Egg mass densities and defoliation remained at low levels in the treated areas and continued to increase in the untreated areas. Mortality and apparent

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[1] Union Carbide Corporation trade name for carbaryl insecticide.

top-kill of poles and sawtimber were also sampled in 1981 (Telfer et al. 1982). Apparent top-kill was greater in the untreated area. Egg mass densities and defoliation both increased significantly in the treated area in 1982 (Telfer 1983). Tree damages remained more severe in the untreated area.

In 1983, egg mass densities and defoliation were sampled; apparent top-kill and mortality of seedlings and saplings, and poles and sawtimber were not sampled. Results are presented in this report.

METHODS

Sampling Locations

The treated and untreated areas were divided into six subunits in 1977 (figures 1 and 2). In each subunit, 25 permanent plots (three-tree cluster) were established, as uniformly as possible, throughout each subunit along roads and trails. Each plot was assigned a unique number. Data were collected on these permanent plots from 1977 to 1979. In 1980, 12 of the original 25 permanent plots in each subunit were used for data collection. The same 12 subunits were again sampled in 1981 and 1982. In 1983, 5 of these 12 plots were sampled. These are the same plots from which the tree damage data have been collected in past years.

Egg Mass Densities

Sampling Design for Egg Masses

In August, two branches (70 cm in length) were cut from opposite sides of sample trees. Length and width of each branch were used to calculate foliated branch area.

Foliage from all branches was examined under ultraviolet light for egg masses. Needles bearing egg masses were classed as from current year's foliage, or a previous year, and kept separate in labeled pill boxes. New and old egg masses were separated under a stereomicroscope. All egg masses on current year's foliage were classed as new, and their characteristics formed the basis for aging those egg masses found on the previous year's foliage.

Analysis of Egg Mass Density Levels

Egg mass densities were expressed as number of new egg masses per square meter (1,550 square inches) of foliage. Subunit and treatment level means and standard errors were computed by the following equations.

Subscripts:

i = treatments	1 = spray, 2 = check
j = subunits	j = 1, 6
k = plot	k = 1, 5
l = tree	l = 1, 3
m = branch	m = 1, 2

Plot level:

$$X_{ijk} = \frac{\sum_{l=1}^{3} \sum_{m=1}^{2} \frac{\text{egg masses}_{ijklm}}{M^2 \text{ foliage}_{ijklm}}}{6}$$

where X_{ijk} is the mean for the k^{th} plot in the j^{th} subunit in the i^{th} treatment.

Subunit level:

$$X_{ij} = \frac{\sum_{k=1}^{n} X_{ijk}}{5}$$

where X_{ij} is the mean for the j^{th} subunit in the i^{th} treatment.

$$\text{S.E. } x_{ij} = \sqrt{\frac{\sum_{k=1}^{n} X_{ijk}^2 = \frac{\sum_{j=1}^{n} X_{ijk}}{n}}{n-1}}^2$$

where S.E. X_{ij} is the standard error of the mean X_{ij}.

Treatment level:

$$X_i = \frac{\sum_{j=1}^{6} X_{ij}}{6}$$

where X_i is the mean for the i^{th} treatment.

$$\text{S.E. } X_i = \sqrt{\sum_{j=1}^{6} \text{S.E. } X_{ij}^2}$$

where S.E. X_i is the standard error of the mean X_i.

Percent Defoliation

Defoliation on Douglas-fir was sampled on five plots in each subunit. On all plots, three codominant Douglas-fir, 30 to 50 feet tall, with relatively open-grown crowns, were sampled.

Sample branches consisted of four apical branches, 70 cm in length, taken from four quadrants at midcrown of each sample tree. From each of these branch samples, 25 new shoots were examined for current defoliation using the left side of 1 branch and the right side of another, and so on. Each new shoot was individually examined for defoliation and assigned an index value as follows:

6-class

Defoliation class %	Index value	Midpoint value %
0	0	0
1-25	1	12.5
26-50	2	37.5
51-75	3	62.5
76-99	4	87.5
100	5	100

Defoliation estimates were analyzed on a "per plot" basis.

The following formula was used to determine the percent defoliation on a "per plot" basis.

$$\text{Percent defoliation} = \frac{n_1\,(12.5) + n_2\,(37.5) + n_3\,(62.5) + n_4\,(87.5) + n_5\,(100)}{N}$$

where n_1 = number of twiglets with index value 1
n_2 = number of twiglets with index value 2
n_3 = number of twiglets with index value 3
n_4 = number of twiglets with index value 4
n_5 = number of twiglets with index value 5

The previous formulas that were used to calculate egg mass densities by plot, subunit, and treatment were used to calculate percent defoliation by plot, subunit, and treatment.

RESULTS

Egg Mass Densities

Average egg mass densities on the treated and untreated subunits are shown in table 1. Average number of egg masses per square meter of

foliage dropped from 38.2 in 1982 to 25.0 in 1983 in the untreated area (figure 2). These densities are not significantly different at the 0.05-percent level. The western spruce budworm has been maintaining epidemic level populations in the untreated area since 1980. Acreage of defoliation, as detected by aerial survey, decreased in 1983 (figure 1), and may decrease again in 1984, since 25.0 egg masses per square meter of foliage predict light defoliation for "static" infestations (McKnight et al. 1970).

Average number of egg masses per square meter of foliage increased from 13.1 in 1982 to 20.6 in 1983 in the treated area (table 1). This increase is not significant at the 0.05-percent level. Egg mass densities increased dramatically on the southern blocks, San Miguel and Joaquin. The other blocks remained at about the same levels as 1982. The infestation is expected to increase substantially in the southern portion of the treated area and remain at the same general level in the remainder of the treated area in 1984.

It is assumed average egg mass densities in the treated and untreated subunits are now essentially equal. No statistical tests between treated and untreated units were performed to prove this assumption, since the treatment blocks were not chosen at random. Other parameters which may influence treatment effects, such as stocking level, species composition and site conditions, are not homogeneous within blocks, again invalidating statistical analysis.

Percent Defoliation

Average percent defoliation of 1983 foliage increased from 44.9 in 1982 to 51.3 in 1983 in the treated area and decreased from 61.3 in 1982 to 58.1 in 1983 in the untreated area (table 2, figure 3). These changes were not significant at the 0.05-percent level. Defoliation of the current year foliage is essentially equal between the treated and untreated areas.

DISCUSSION

Budworm populations, but not damages, were monitored in 1983. The populations, as measured by egg mass densities, are at equal levels now. Tree damages and visual quality impacts are moderate to severe in the untreated area, whereas many of the treated areas are still undamaged. Should the outbreak persist, permanent tree damages are expected to begin occurring in the treated area within the next several years.

Egg mass densities and current year's defoliation will continue to be monitored annually until the budworm populations collapse. Permanent tree damages will be assessed periodically during the course of the infestations. Damages within similar individual stands in treated and untreated areas will be compared periodically.

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TABLE 1.--Western spruce budworm egg mass densities on treated (1-6) and untreated (7-12) check subunits, Santa Fe National Forest and Jemez Pueblo Indian Reservation lands, New Mexico

Treated subunits	Egg masses per m^2 of foliage													
	1977		1978		1979		1980		1981		1982		1983	
	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.
1. San Miguel	4.2	1.1	0.9	0.3	0.7	0.3	3.4	1.1	4.4	1.6	14.7	5.0	40.0	19.3
2. Joaquin	1.4	0.5	0.0	0.0	0.2	0.1	6.4	1.8	5.9	1.2	20.7	3.6	44.8	18.1
3. Smokey Bear	0.2	0.1	0.2	0.1	0.4	0.2	3.5	0.7	3.9	0.9	9.9	1.9	8.8	0.3
4. Trail	1.9	0.6	0.6	0.2	1.2	0.4	7.6	4.0	5.4	2.4	13.3	5.8	10.8	3.8
5. Blue Bird	1.2.	0.4	0.4	0.2	0.8	0.3	5.7	4.7	4.6	1.5	7.7	2.9	10.0	3.5
6. Red Top	1.0	0.3	0.5	0.2	0.6	0.3	2.8	0.7	12.4	3.1	12.5	1.82	9.3	1.8
Average	1.7^{a*}		0.4^{a}		0.6^{a}		4.9^{ab}		6.1^{ab}		13.1^{bc}	1.82	20.6^{c}	6.9
Untreated subunits														
7. Ojitos	1.0	0.3	1.0	0.3	1.5	0.6	14.9	6.0	14.1	2.6	33.0	8.1	28.3	10.3
8. Lake Fork	7.5	1.7	11.2	2.6	17.9	3.7	39.6	11.0	37.2	7.7	38.3	6.4	32.7	2.8
9. Cochiti	11.6	2.9	12.4	2.5	21.0	5.2	69.7	9.0	37.4	7.8	46.1	5.9	25.4	5.3
10. Capulin	14.4	2.5	12.5	1.9	19.2	3.3	51.7	9.2	32.6	5.4	60.5	7.1	28.7	3.3
11. American Springs	7.4	1.1	11.1	1.7	15.0	2.8	60.1	8.9	22.4	3.1	23.0	3.7	19.3	2.2
12. Los Alamos	17.5	2.6	12.5	1.9	20.6	3.2	51.9	6.6	29.1	3.7	28.2	3.8	15.6	4.0
Average	9.9^{a}		10.1^{a}		15.9^{ab}		48.0^{d}		28.8^{bc}		38.2^{cd}	5.5	25.0^{abc}	2.6

* Figures followed by different letters are significantly different at the 0.05 level using a Newman-Keuls test (i.e., a is significantly different from b and c, etc.).

TABLE 2.--Percent defoliation of Douglas-fir treated (1-6) and untreated subunits, Santa Fe National Forest and Jemez Pueblo Indian Reservation lands, New Mexico

Subunits	Percent defoliation						
Treated	1977	1978	1979	1980	1981	1982	1983
1. San Miguel	41.6	4.5	3.7	9.2	25.5	27.3 ± 6.3[1]	50.0 ± 12.5
2. Joaquin	19.9	1.5	2.0	7.1	51.9	56.0 ± 6.6	66.7 ± 10.3
3. Smokey Bear	18.0	1.1	1.0	7.6	31.5	53.0 ± 5.8	48.8 ± 8.3
4. Trail	37.0	5.4	2.2	12.5	25.3	34.0 ± 5.4	38.2 ± 14.6
5. Blue Bird	25.5	2.7	3.0	13.6	23.6	33.4 ± 5.4	39.6 ± 12.1
6. Red Top	16.6	2.0	3.2	8.1	33.6	65.5 ± 5.9	64.7 ± 10.7
Average	26.5[a*]	2.9[b]	2.5[b]	9.6[b]	31.9[a]	44.9[c]	51.3[c]
Untreated							
7. Ojitos	14.1	9.4	6.8	24.4	65.0	73.6 ± 7.1	72.6 ± 10.5
8. Lake Fork	51.1	40.9	34.1	48.4	72.6	68.3 ± 4.3	64.1 ± 9.6
9. Cochiti	37.2	35.3	29.4	55.4	71.8	57.9 ± 6.2	61.3 ± 6.7
10. Capulin	51.2	29.0	28.3	65.7	61.0	52.6 ± 3.4	39.7 ± 6.9
11. American Springs	34.2	29.1	31.6	73.5	65.4	58.2 ± 3.5	54.0 ± 7.0
12. Los Alamos	56.7	23.8	29.9	60.9	67.2	57.2 ± 5.1	56.9 ± 10.1
Average	40.8[a]	27.9[a]	26.7[a]	54.7[b]	67.2[b]	61.3[b]	58.1[b]

* Figures followed by the same letter within treatment areas are not significantly different at the 0.05% level using a Newman-Keuls test.

[1] Standard error.

FIGURE 1.--Location of the treated (1-6) and untreated (7-12) spray blocks and defoliation in 1983 as detected by aerial survey

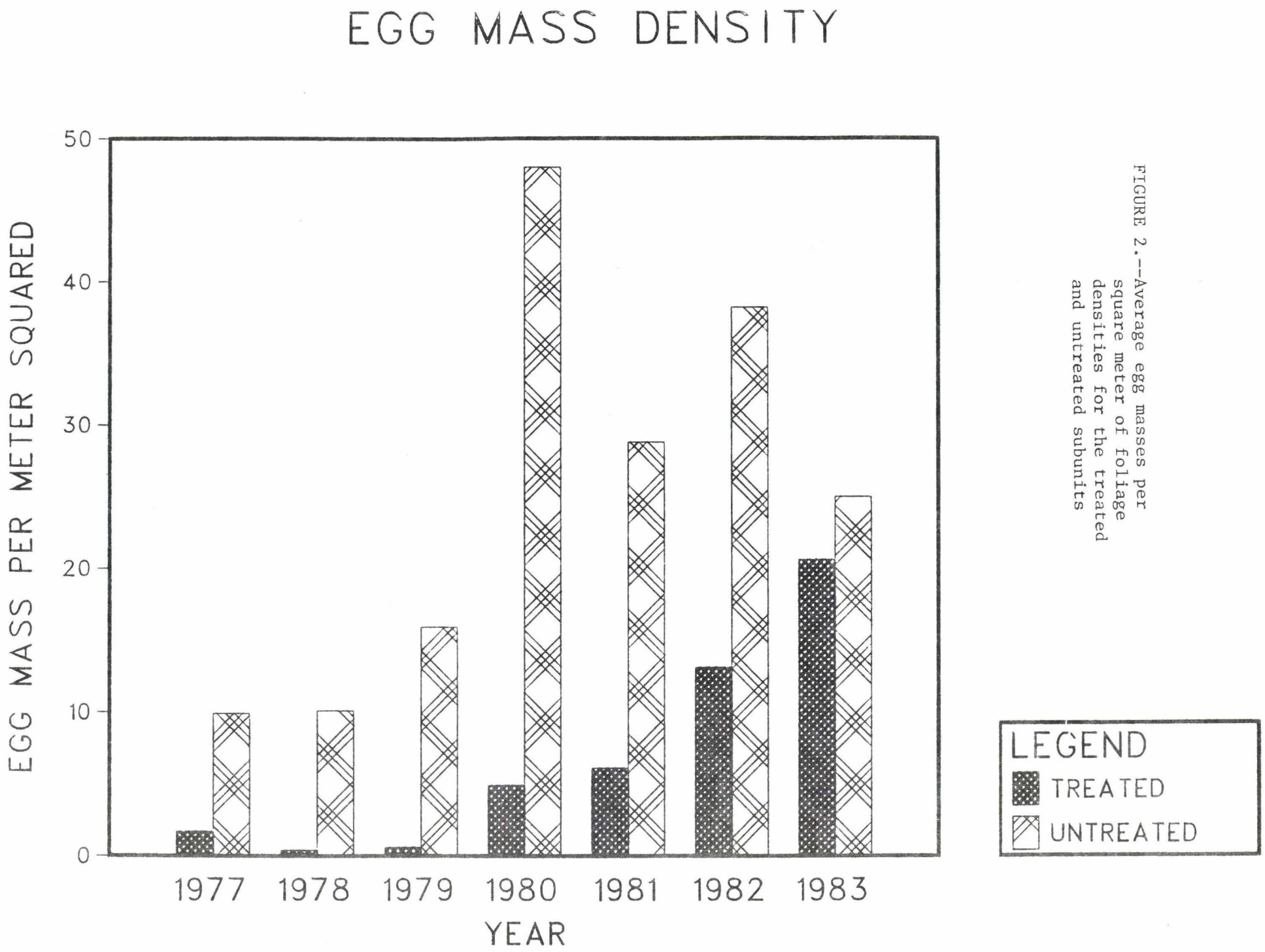

FIGURE 2.--Average egg masses per square meter of foliage densities for the treated and untreated subunits

FIGURE 3.--Average percent defoliation by the 6-class rating system for treated and untreated subunits